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ABSTRACT

This booklet is intended to help mainstreamed mentally retarded, emotionally disturbed, or learning disabled high school students acquire a basic understanding of the responsibilities and working conditions of machinists and to practice basic math skills necessary in the occupation. The first section provides a brief introduction to the occupation by focusing upon those job tasks of a machinist with which the student is likely to be familiar. The next two sections deal with the work environment of the typical machinist and the training, education, and experience needed for the occupation. Exercises addressing basic math skills used by machinists are provided. Various suggestions are listed for students interested in further exploring the occupation of machinist. A glossary and answer sheet conclude the booklet. (YLB)

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MATH on the job

Machinist

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MATH ON THE JOB:

MACHINIST

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MATH on the job

Machinist

In this booklet, you can--

- find out what a machinist does
- see how a machinist uses math
- get a chance to use math as a machinist
- find out the types of things a machinist needs to know
- find out what courses, training, and experience you need to become a machinist

SPECIAL WORDS USED IN THIS BOOKLET

Workers in many jobs use special words or special meanings for words. Learning these words helps you to learn about a job.

You will find some of these special words in this booklet. When these words, and some hard words, are used for the first time, they are followed by one or more **asterisks.*** These words are also in the **glossary**** at the back of the booklet.

DEFINITIONS

*An asterisk (*) is a symbol that tells you to look at the bottom of the page for the meaning, or definition, of the word.

**A glossary is a list of words with their meanings.

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HAVE YOU EVER...

- seen a **machine tool***?
- seen a person operate a machine tool?
- shaped or formed metal with **hand tools****?
- read a sketch or **blueprint*****?

If you have, then you have some idea about the work of a machinist. This booklet will help you learn about the work of machinists and how math is important to do the job.

DEFINITIONS

*A machine tool is a power driven machine. It is used to shape or form metal. A machine tool can not be carried by hand.

**A hand tool is a hand held instrument such as a hammer, punch, or file. A hand tool is used to shape, form, or finish various materials.

***A blueprint is a picture that shows how something is to be built or put together.

WHAT DOES A MACHINIST DO?

A machinist uses power driven tools to cut, shape, and finish metal parts for machines. As a machinist, you may make a part such as a gear or shaft for airplanes, cars, machines, or other equipment. To make parts, you--

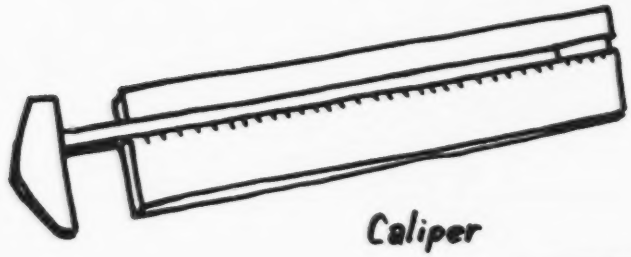
- read the blueprint of the part to be made
- make sketches and notes
- determine the size, amount, and type of materials you will need
- set up and operate machine tools
- maintain and repair machine tools

Machinists use math in their work every day. As a machinist, you--

- count, add, subtract, multiply, and divide
- use whole numbers, decimals and fractions
- use the metric system for taking measurements and reading gauges

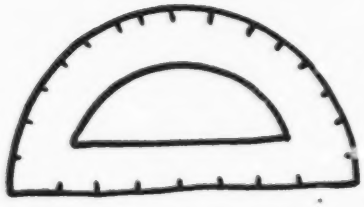
You will also use math to--

- determine the depth of cut in a piece of metal with a **vernier caliper***
- determine the length of a piece of metal using a **scale****
- determine the angle of cut in a piece of metal with a **protractor*****



Caliper

Scale



Protractor

DEFINITIONS

*A <u>vernier caliper</u> is an instrument with a threaded band used for making precise external measurements.

**A <u>scale</u> is a metal rule with a system of very detailed marks used for precise measurements.

***A <u>protractor</u> is an instrument used to measure and construct angles.

A machinist uses math to determine the amount of error allowed.

EXAMPLE

A tolerance is the maximum permitted error in the dimension of a part. Some parts, such as those found in a jet engine, must be very precise. Other parts, such those found in furniture, need less precision. Tolerances are stated in terms of plus or minus. This part measures 5.0 centimeters (cm) and has a tolerance of plus or minus (±) .2 cm.

Use this formula to find the tolerance:

desired length plus tolerance	=	maximum acceptable length
desired length minus tolerance	=	minimum acceptable length

5.0 cm + .2 cm = 5.2 cm (maximum)
5.0 cm - .2 cm = 4.8 cm (minimum)

NOW YOU TRY IT

Practice Exercise A

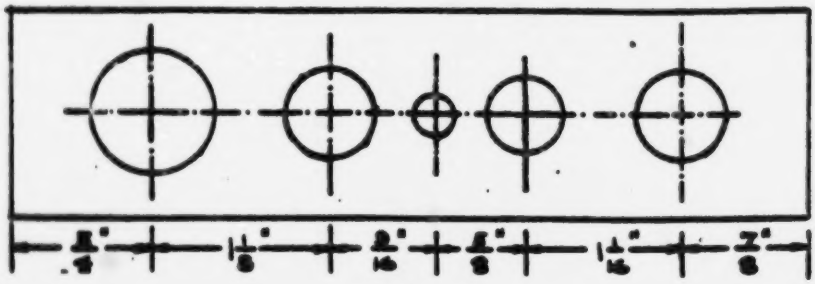
Find the minimum and maximum acceptable length for each dimension listed below. Write your answers on a separate sheet of paper. The first problem is done for you.

	Dimension (centimeters)	Tolerance (centimeters)	Maximum (centimeters)	Minimum (centimeters)
	0.50	± .01	0.51	0.49
1.	1.20	± .01	?	?
2.	4.50	± .05	?	?
3.	3.60	± .05	?	?

A machinist uses math to calculate dimensions of machine parts.

EXAMPLE

Let's assume that you are making a metal part for a machine. A sketch of the part appears below.



What is the total length in inches of the part? To find the total length, add each separate measurement. To add measurements with fractions, follow these steps:

Step 1. Find a common denominator. In this example, the common denominator is 16.

Step 2. Convert the fractions to the common denominator. In this example, you will convert--

3/4"	to	12/16"
1-1/8"	to	18/16"
9/16"	to	9/16"
5/8"	to	10/16"
1-1/16"	to	17/16"
7/8"	to	14/16"

Step 3. Add the fractions together. For this example, the total is 80/16".

Step 4. Simplify the answer to its lowest form. For this example, the answer is 5".

The total length of the part is 5 inches.

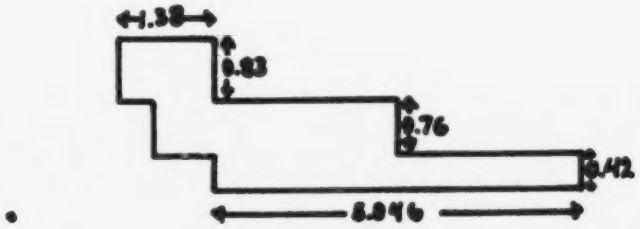
NOW YOU TRY IT

Practice Exercise B

Find the dimensions of the metal parts in the drawings below. All measures are given in centimeters.

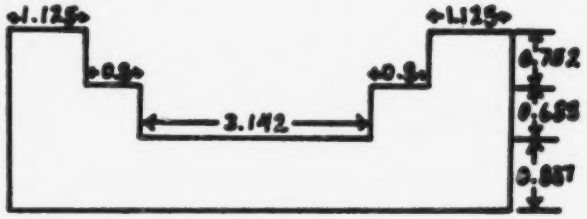
4. Find the total length.

5. Find the total width.



6. Find the total length.

7. Find the total width.



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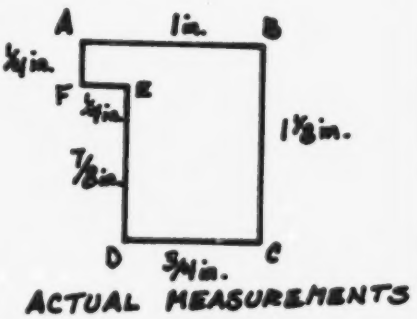
A machinist uses math to make drawings and sketches of metal parts.

EXAMPLE

As a machinist, you may want to make a scale drawing of a metal ~~part like~~ the one below. For this example, let's assume that each length in your scale drawing will be 1/2 as long as the actual length. To find the scale measurements, you must multiply the actual measurements by 1/2.

AB = 1 in. x 1/2 = 1/2 in.
BC = 1-1/8 in. x 1/2 = 9/16 in.
CD = 3/4 in. x 1/2 = 3/8 in.
DE = 7/8 in. x 1/2 = 7/16 in.
EF = 1/4 in. x 1/2 = 1/8 in.
FA = 1/4 in. x 1/2 = 1/8 in.



ACTUAL MEASUREMENTS

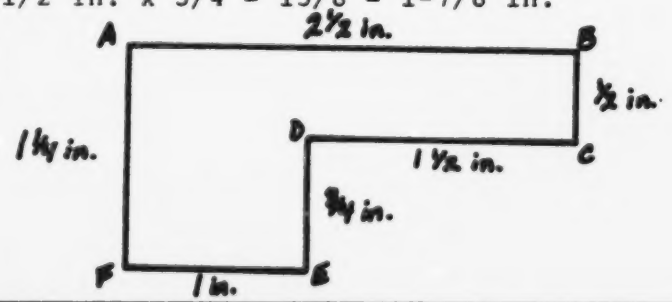
NOW YOU TRY IT

Practice Exercise C

In the scale drawing for this part, each length will be 3/4 times as long as the actual length. Find the scale measurement for each length listed. The first problem is done for you.

AB = 2-1/2 in. x 3/4 = 15/8 = 1-7/8 in.

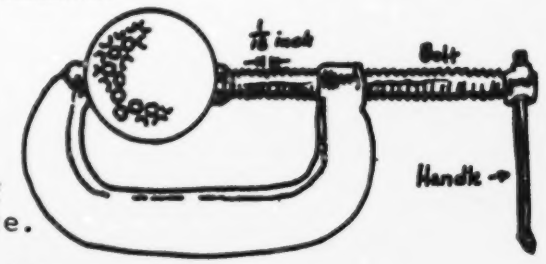
8. BC = ?
9. CD = ?
10. DE = ?
11. EF = ?
12. FA = ?



A machinist uses math to work with equipment.

EXAMPLE

A machinist uses a "C" clamp to hold materials in place. A "C" clamp can also be used to measure the width of an object, such as the golf ball shown in the picture.



On the bolt of the "C" clamp in this example, the distance from the top of one thread to the top of another is 1/18 inch. When the handle is turned completely around once, the bolt moves 1/18 inch.

When the golf ball is removed from the clamp, it takes 18-1/2 turns of the handle to close the clamp. To find the diameter of the ball, multiply the turns of the handle by the amount the bolt moves for each turn.

Turns of the handle		Amount bolt moves for each turn		Width of object (inches)
18-1/2	x	1/18 in.	=	1-1/36

The diameter of the golf ball is 1-1/36 inches.

NOW YOU TRY IT

Practice Exercise D

Listed below are several objects. Also listed are the number of turns of the handle needed to close the "C" clamp when each object is removed. Multiply by 1/18 inch to find the width of each object.

	Object	Turns of the Handle	Width of the Object
13.	Bolt	9	?
14.	Hammer	22-1/2	?
15.	Nail	2-1/4	?
16.	Pencil	5	?
17.	Ruler	4	?
18.	Chalk	6	?
19.	Drill bit	6-3/4	?

WHERE DOES A MACHINIST WORK?

As a machinist, you may work in one of three types of machine shops--

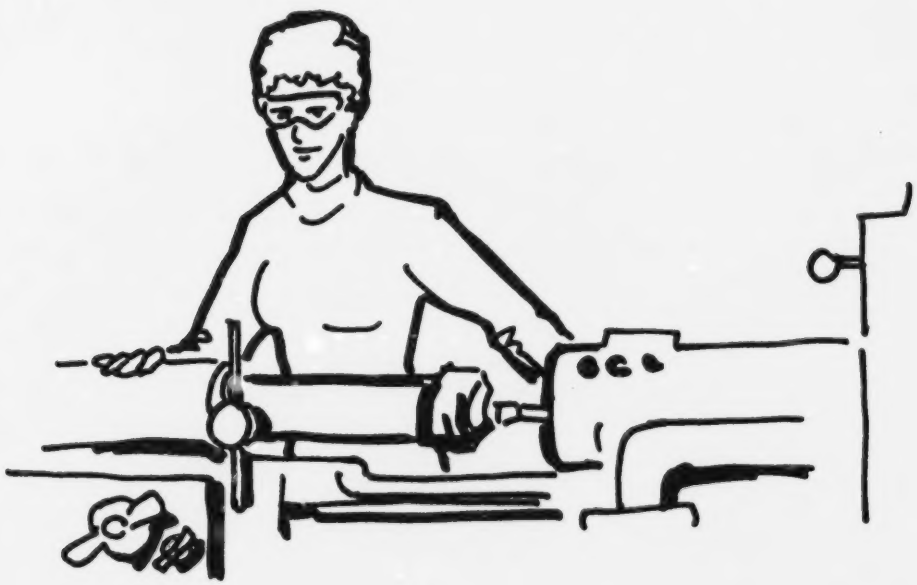
- a production shop, where you will make many copies of the same metal part.
- a job shop, where you will make only a few copies of a metal part.
- a maintenance shop, where you will repair metal parts or make new ones.

The kind of machines you will use and the products you make will depend on where you work.

Working in a machine shop can be dangerous. In some shops, workers must wear earmuffs or earplugs to protect their hearing. In all shops, machinists must wear safety glasses with side shields. Machinists are not allowed to wear loose clothing, long hair, or rings and jewelry. A piece of loose clothing or a long necklace could get caught in a machine and cause an accident.

Machinists use special types of equipment to perform their work. As a machinist, you use--

- measuring tools to find the dimension of **raw materials*** and finished products. These tools are accurate to one one-thousandth of an inch (1/1000 inch).
- hand tools to adjust, tighten, loosen, and repair the various parts of a machine tool.
- machine tools to correctly cut and shape your work.
- a lathe to turn raw material while you cut and shape it.
- a milling machine to remove the surface of a piece of metal or to cut grooves in it.
- a drill press to make holes of various sizes in metal.



DEFINITION

*Raw materials are pieces of metal from which finished products are made.

IF YOU ARE INTERESTED IN

THE WORK OF A MACHINIST

AND WOULD LIKE TO KNOW MORE,

READ ON

WHAT TRAINING, EDUCATION, AND EXPERIENCE DO YOU NEED TO BECOME A MACHINIST?

What do you think? Would you like to be a machinist? If you would, there are some things you should know.

To get a job as a machinist, you need to know how to--

- use specialized hand tools
- operate machine tools to turn, drill, mill, and grind metal
- use precision measuring instruments
- read blueprints
- use shop mathematics*

The best way to learn these things is to enter a vocational education program at your high school.

DEFINITION

*Shop mathematics are the types of calculations typically done in a machine shop.

To be a machinist, you will also learn skills on the job. You will help experienced machinists to do their work. Experienced machinists will show you what to do and train you on the job.

To improve your skills as a machinist, you may want to--

- attend classes at a trade or technical school
- visit trade shows
- read publications written especially for machinists

Taking every chance to learn new skills and tasks will help you do a better job. Good math skills will also help you perform your work as a machinist.

DO YOU WANT TO DO MORE MACHINIST'S MATH?

Practice Exercise E

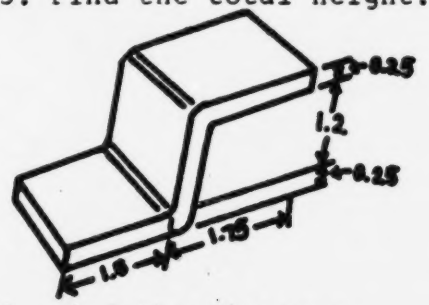
Find the maximum and minimum acceptable length for each dimension listed below.

	Dimension (centimeters)	Tolerance (centimeters)	Maximum (centimeters)	Minimum (centimeters)
	2.90	± .01	2.91	2.89
20.	6.70	± .02	?	?
21.	5.40	± .02	?	?
22.	1.40	± .01	?	?
23.	6.30	± .01	?	?

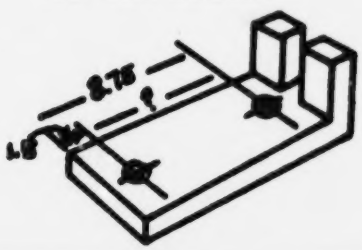
Practice Exercise F

Find the dimensions of the metal parts in the drawings below. All measures are given in centimeters.

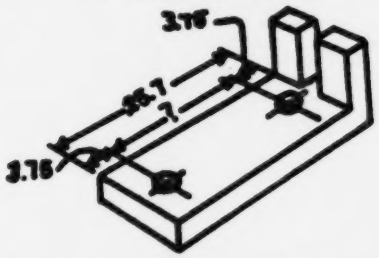
24. Find the total length.
25. Find the total height.



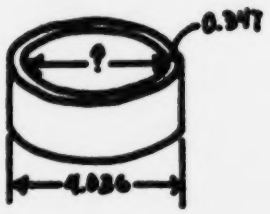
26. Find the distance between the centers of the holes.



27. Find the distance between the centers of the holes.



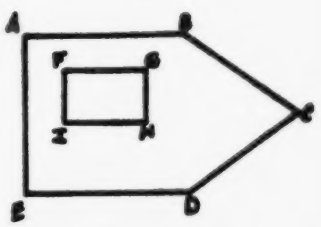
28. Find the inside diameter.



Practice Exercise G

In the scale drawing for the part below, each length will be 5/8 times as long as the actual length. For the practice exercise, measure the length of each side to the nearest 1/8 inch and calculate the actual length. The first problem is done for you.

	Side	Actual Length	Scale drawing
	AB	1-1/4 in.	23/32 in.
29.	BC		
30.	EA		
31.	FG		
32.	GH		



Practice Exercise H

Listed below are several objects. Also listed are the widths of the objects. Imagine that each object has been placed in a "C" clamp. Find the number of turns of the handle needed to close the "C" clamp when each object is removed. Find the number of turns by dividing each width by 1/18 inch. The first problem is done for you.

	Object	Width (inches)	Number of turns of the handle
	Drill bit	3/8	6-3/4
33.	Thumb	7/12	?
34.	Chalk eraser	1	?
35.	Magazine	1/3	?

DO YOU WANT TO EXPLORE SOME MORE?

1. Visit your school library. Ask the librarian if the library has any material that would give you more information about machinists and the work they do.

2. Check to see if your school offers vocational training in machine trades. If such training is offered, contact the instructor and arrange to visit a class. Talk to some of the students in the class. Find out the types of classes they are taking, the machines and tools they work with, and why they are taking machine trade courses.

3. Arrange a visit to a machine shop located in your community. Watch a machinist at work. Talk to a machinist about the work he or she performs. Ask machinists what they like and dislike about their work.

4. Check your local phone book's listings under "Labor Organizations" to see if there is a machinist union in your community. If there is, call the union office and ask about the machine trade apprentice program. Ask the person you talk to if they could send you information about the program. Ask if you could visit and talk with someone about the apprentice program.

5. Are you interested in other jobs which are similar to that of the machinist?

   - General inspectors check the quality of the finished part.
   - Tool crib* attendants maintain, distribute, and collect the various tools used in the machine shop.
   - Numerical control programmers set up the computers that control machine tools.

   You must have good math skills to do these jobs well. Most of these workers add, subtract, multiply, and divide every day on the job.

DEFINITION

*A tool crib is a special room containing many tools used by a machinist. The person in charge of the tool crib is the tool crib attendant.

GLOSSARY

Asterisk (*): a mark that tells you to look at the bottom of the page for the meaning, or definition, of the word.

Blueprint: a picture that shows how something is to be built or put together.

Glossary: a list of words with their meanings.

Hand tool: a hand-held instrument such as a hammer, punch, or file. A hand tool is used to shape, form, or finish various materials.

Machine tool: a power driven machine. It is used to shape or form metal. A machine tool can not be carried by hand.

Protractor: an instrument used to measure and construct angles.

Raw materials: pieces of metal from which finished products are made.

Scale: a metal rule with a system of very detailed marks used for precise measurements.

Shop mathematics: the types of calculations typically done in a machine shop.

Tool crib: a special room containing many tools used by a machinist. The person in charge of the tool crib is the tool crib attendant.

Vernier caliper: an instrument with a threaded barrel used for making precise external measurements.

ANSWER SHEET

Practice Exercise A

	Maximum	Minimum
1.	1.21	1.19
2.	4.55	4.45
3.	3.65	3.55

Practice Exercise B

4. 6.426 cm
5. 2.01 cm
6. 6.992 cm
7. 2.272 cm

Practice Exercise C

8. BC 3/8 in.
9. CD 1-1/8 in.
10. DE 9/16 in.
11. EF 3/4 in.
12. FA 15/16 in.

Practice Exercise D

13. 1/2 inch
14. 1-1/14 inch
15. 1/8 inch
16. 5/18 inch
17. 2/9 inch
18. 1/3 inch
19. 3/8 inch

Practice Exercise E

	Maximum	Minimum
20.	6.72	6.68
21.	5.42	5.38
22.	1.41	1.39
23.	6.31	6.29

Practice Exercise F

24. 3.25 cm
25. 1.7 cm
26. 7.25 cm
27. 18.2 cm
28. 3.342 cm

Practice Exercise G

	Side	Actual Length	Length in Scale drawing
29.	BC	1-1/8 in.	45/64 in.
30.	EA	1-3/8 in.	55/64 in.
31.	FG	5/8 in.	24/64 in.
32.	GH	3/8 in.	15/64 in.

Practice Exercise H

	Object	Width (inches)	Number of turns of the handle
33.	Thumb	7/12	10-1/2
34.	Chalk eraser	1	18
35.	Magazine	1/3	6